from speculators, saying that he was paid by the French government and that all his discoveries belonged to the public. As Huxley says: "The discoveries of Pasteur are sufficient alone, to have repaid all the tribute of war of five milliards of francs paid by France to Germany."

In our time, when money seems to be everything, and when we have the discouraging spectacle of competitions to get at great fortunes by all means, it is a great example to see a man refusing to be tempted and perfectly satisfied with a modest pension of 12,000 francs yearly, soon raised to 25,000 francs during his life, to be continued to his widow and afterwards equally divided between his two children. To be sure the honor is unique. His public funeral, also at the national expense, attended by the President of the French Republic, and followed by the mass of the population, without regard to parties, is another noble manifestation, unmixed with any discordant notes, from the humblest citizen, and even children, to his highest surviving contemporaries.

One more word, Pasteur's last creation was his Institut, rue Dutot, built by private subscriptions and sustained by rents from a yet too small capital, increased happily yearly by annual appropriations from the French budget. There the new roads he opened to science will continue to attract the attention of the scientific world, and discoveries will go on under his direction and methods. Pasteur was very anxious to place it on a sure and somewhat independent basis, and in the last letter he wrote me with his own hand, when already stricken with the ailment which terminated his life, he says:

"INSTITUT PASTEUR,
PARIS, le 14 décembre, 1887.

MON CHER MARCOU:

Je suis heureux des bonnes nouvelles que tu me donnes de ta santé. La mienne a été éprouvée dans ces derniers temps par une congestion qui m'a rendu la parole un peu difficile. Quoiqu'il en soit je suis, depuis quelques semaines, une hygiène de repos et de calme qui me réussit assez bien.

Tout va bien au laboratoire et l' Institut Pasteur, est presque terminé, moins l' aménagement intérieur. L' inauguration cependant n 'aura lieu qu' à la fin de l' été prochain et nous n'en prendrons possession qu'en Novembre, 1888. Ce sera grand et confortable et de bel aspect. La souscription a dépassé deux millions. Avec le legs récent de Madame Boucicaut (du *Bon Marché*) et un autre legs d'un négociant de Lyon, elle dépassera deux millions deux cent mille francs. Les constructions et l'achat du terrain atteindront douze cent mille francs et plus.

Nous avons donc besoin d'accroître encore beaucoup notre capital. J'ai confiance en de nouveaux legs.

Ah! si nous étions en Amérique, le pays aux généreuses et grandes initiatives!

Déjà nous rendons mille actions de grâces à la très digne Madame Boucicaut qui n 'a pas contribué à la souscription pour moins de deux cent cinquante mille francs.

Je m' arrête. Ecrire me fatigue encore par l' obligation de courber la tête.

Tous les affectueux souvenirs de Mme Pasteur et de moi, à Mme Marcou et à Monsieur Philippe, à toi mille bonnes amitiés.

L. PASTEUR."

JULES MARCOU.

CAMBRIDGE, MASS, 14th November, 1895.

HOLBROOK CUSHMAN.

HOLBROOK CUSHMAN was born in New York City, in 1857, and was there prepared for college, entering Columbia in 1874. He was graduated with honors in 1878, receiving the 'Fellowship in Science.' From Columbia he went to the University at Würzburg, Bavaria, studying physics with Kohlrausch, mathematics with Prym and

Selling, and chemistry with Wislicenus. After three years work at Würzburg he went for a year to Helmholtz at Berlin. After his return to America in 1882, and until 1890, he was chiefly occupied with commercial applications, having been for several years with a large firm manufacturing electrical supplies in England, and subsequently he was connected with a similar firm in this country. In 1890 he was appointed assistant in physics at Columbia, and quickly rose to the rank of instructor, which he held at his death, on October 25, 1895.

As a man and a friend he was all that the words in their best sense imply.

If one were to judge Mr. Cushman's services to science by his published work, one would obtain a most incomplete idea of their extent. Although deeply interested in the more theoretical questions which have specially occupied physicists in the past score of years, and always willing to discuss them, still his heart was chiefly set upon the practical applications, not in a commercial sense, but referring to teaching or research. Many pieces of very useful apparatus and many excellent laboratory methods are the results of his activity in this field. His chief service to science, and the one which will remain as a lasting monument to the strongest side of his activity, is the admirable organization of the laboratory teaching of physics at Columbia. To his untiring industry and thorough devotion is due a system which handles 400 students annually in a limited space, giving to each a course adopted to his individual needs. For each of the experiments, some 200 in number, he has prepared full explanations and instructions for making the determination. It is proposed to issue this collection with some little additional material as a laboratory manual for the use of our students. It is also proposed to contribute to Science several papers on methods and apparatus prepared by him and left unpublished at his death.

Collimating Magnetometer and Local Variometer.

Unpublished paper by Holbrook Cushman.

Edited by W. Hallock.

MAGNETOMETER.

In laboratory determinations of the intensity of the Earth's magnetic field it is often desirable to be able to obtain the deflection observations with an accuracy greater than is possible with the usual glass pointer over a 15 or 20 cm. divided circle and yet not incur the expense and elaborateness of the telescope and scale, or the lamp and scale.

The method devised is intermediate in accuracy between the two methods above mentioned and gives the readings in tangents of the angle directly.

A in the accompanying Fig. 1 is the magnetometer with a plain mirror about 2 cm. in diameter with a vertical black line across the center of its face, B & B′ are the scales upon which the deflecting magnet M is placed, S is a scale, a common meter stick will do, mounted perpendicular to B at a distance of one meter from the magnetometer needle at A. Upon the scale slides the sight, P, shown $\frac{1}{2}$ natural size in Fig. 3. It consist of a piece of sheet brass about 0.5 mm. thick, slit and bent so that two side strips, n n, slide upon one side of the scale and the middle one, o, upon the other side, toward the magnetometer; h is a hole about 1 mm. diameter, and the side toward the mirror is covered with white paper upon which is a cross X. By a series of simple sightings the magnetometer A is oriented in line with the scales B and B,′ and upon their common zero. Placing the sight upon the point of the scale S directly over the axial line of B, A and B,′ the whole apparatus is to be so oriented

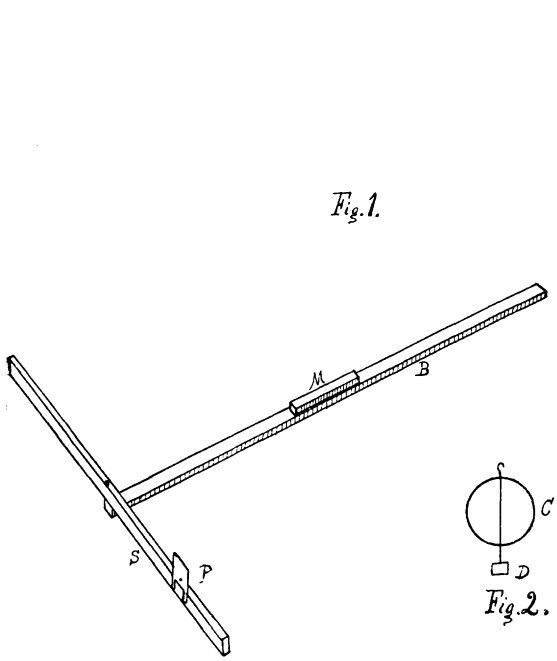
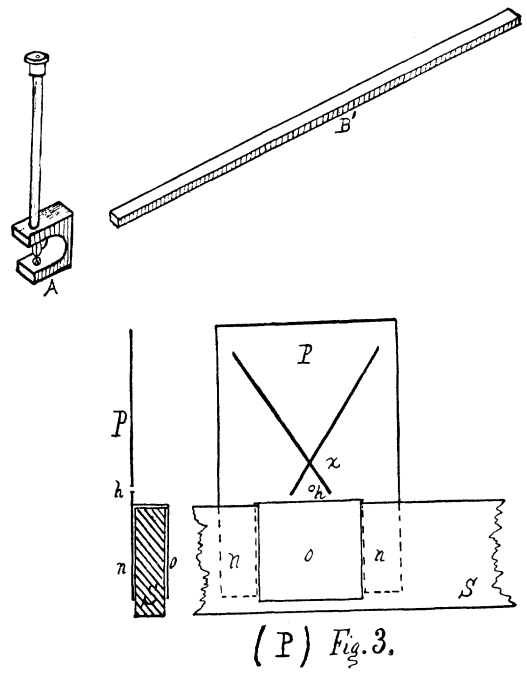


Fig. 1.

Fig. 2.



(P) Fig. 3.

that on looking through the hole h, the cross X is seen reflected in the mirror of A with its intersection upon the vertical line. The magnets are upon the back of the mirror shown $\frac{1}{2}$ natural size at Fig. 2. D is a wing dipping into an oil cup and acting as a damper. Of course, this method of sighting brings the hole h and cross X into the plane normal to the mirror. The magnet M being placed in position, the mirror is deflected and the sight P is slid along the scale S until the cross is again seen coincident with the line upon the mirror. The difference between this and the previous setting of the slide expressed as a decimal of a meter will be the natural tangent of the angle of deflection, and is easily correct to the third, with a fair approximation to the fourth place of decimals. P being always set on the normal to the mirror and its position measured upon the tangent to a circle whose radius is one, the reading is always the natural tangent of the angle. This method of reading angles will be found convenient in many other cases.

VARIOMETER.

The method of reading angles above described has been applied to an apparatus for measuring the local variations in the horizontal component of the Earth's magnetism with an error somewhat less than 1%.

Fig. 4 shows the apparatus about one-third natural size. It consists of a magnetometer M, similar to that shown in Fig. 1, so mounted as to be movable on a slide A. B is a coil of copper wire of about 5 ohms resistance whose support is also movable upon a scale parallel to A, so that M is upon the axis of B. Two Daniel cells at C and C' (C' is removed in the cut) send a constant current through the commutator D and the coil B. The sight P is similar to that shown in Fig 3. The scale S is divided to read horizontal intensity directly. That is with zero at the center, distances d either way upon the scale are computed according to the formula, $d = \frac{KC}{H}$. H is the horizontal component of the earth's magnetism, C the cur-

rent in the coil and K its factor. *KC* can be found empirically by assuming values for d and H, which will be convenient and leave the magnetometer at a suitable distance from the scale S. Of course if it is preferred one can use a millimeter scale and read the tangents and reduce each time. The operation with the apparatus is as follows:

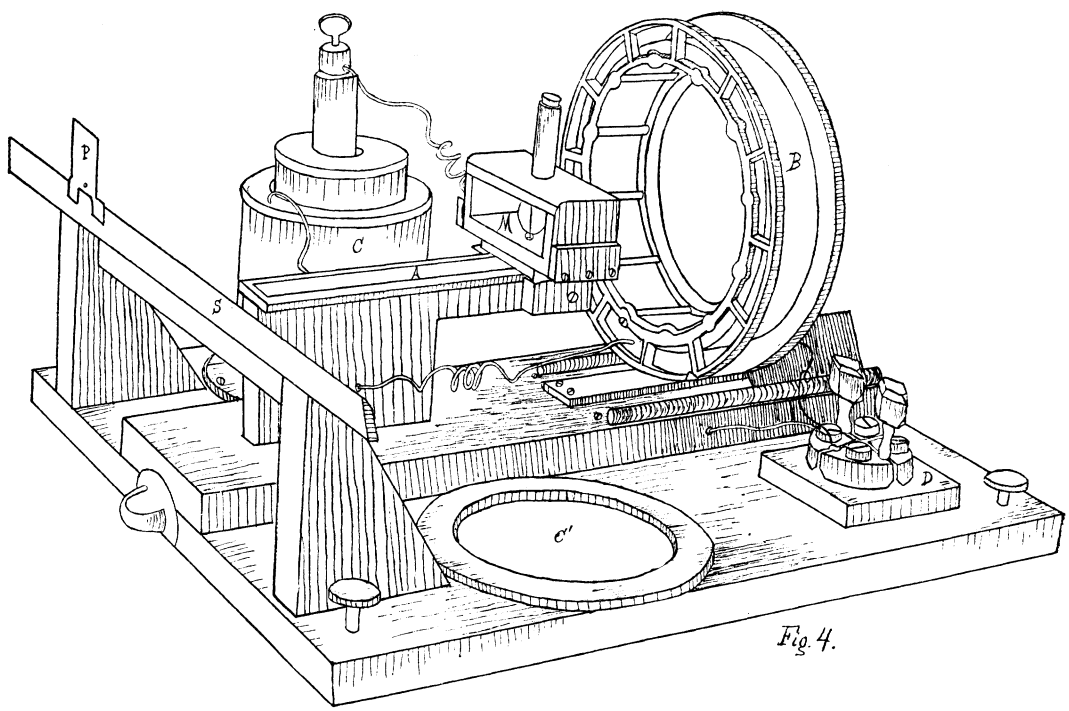


Fig. 4.

Before the current in B is started, the sight is put at zero and the instrument oriented at the standard locality as described for Fig. 1. This oriented position should be so marked that the variometer can be easily and quickly returned to it. Similarly the oriented positions at the various stations should be established before commencing the observations.

The current is started and allowed to flow till fairly constant. When observations are to be made, the sight is placed at the point upon the scale reading the same as the horizontal intensity found for the fiducial locality. The coil B is then slid backward or forward until the mirror normal falls upon the cross of the sight. Everything is then left in position and the variometer taken to the second station; the sight being adjusted normal to the new deflection of the mirror, the reading will be the intensity at that place. Thus the instrument gives the horizontal component directly. Naturally one must always take the precaution to commutate the current, and take frequent check readings at the fiducial location.

In this way observations about a room or building can be conveniently made and results obtained whose errors are certainly not greater than the daily and other fluctuations of intensity. Naturally by increasing the distance from the mirror to the scale and the precautions for constancy of current, one can obtain more acurate re-

sults, but would correspondingly lose in compactness and portability. The appararatus as illustrated has been used in the physical laboratory at Columbia and has proved itself very simple and useful.*

COLUMBIA COLLEGE, November 18, 1895.

MEASUREMENTS OF THE ACCURACY OF RECOLLECTION.

WE know that ordinary observation and recollection are not altogether reliable. We do not credit all the stories that we hear, even though we may not doubt the good faith of the narrators; we see that conflicting evidence is offered in courts of justice when no perjury is intended; we regard as partly mythical records supposed for many centuries to describe historical events. But we do not know how likely it is that a piece of testimony is true, nor how the degree of probability varies under different conditions. If we could learn this by experiment the result would be a contribution to psychology, and would at the same time have certain important practical applications.

I have tried in various ways to secure a quantitative determination of the reliability of recollection and evidence, and will here report on the answers to some questions asked the junior class in psychology in Columbia College in March, 1893. The questions were answered in all or in part by the fifty-six students present.

Several simple questions were first asked and the students allowed in each case one-half minute to consider and write the answer. They were also requested to assign the confidence which they felt in the correctness of their answer—*a* if quite certain, *b* if tolerably certain, *c* if doubtful, *d* if the answer were a guess.

The first question was 'what was the weather a week ago to-day?' The answers were pretty equally distributed over all kinds of weather which are possible at the beginning of March. Of the 56 answers, 16 may be classed as 'clear,' 12 'rain,' 7 'snow,' 9 'stormy,' 6 cloudy and 6 partly stormy and partly clear.* It seems that an average man with a moderate time for reflection cannot state much better what the weather was a week ago than what it will be a week hence. Yet this is a question that might naturally be asked in a court of justice. An unscrupulous attorney can discredit the statements of a truthful witness by cunningly selected questions. The jury, or at least the judge, should know how far errors in recollection are normal and how they vary under different conditions.

When asked 'what was the weather two weeks ago?' 20 students answered 'clear,' and 18 'stormy.' The confidence in this case was slight, only two being sure that their answers were correct and 8 having some confidence, while the others were doubtful or did not answer at all.

We ought not, indeed, to conclude from these conflicting answers that no inference as

* The above drawing of the local variometer was made by a method which may prove useful to others, and which, so far as I know, is new. It is often desirable to get a perspective line drawing of a rather complicated piece of apparatus without employing a skilled artist, or consuming too much time. To produce the above cut a small photographic negative of the variometer was taken, from which a contact positive was made. The positive was placed in a projection lantern and thrown upon a screen consisting of a piece of drawing paper upon a board, the size of the image being two or three times as large as the cut. The outlines were then traced in with pencil, and one can also shade directly where desired. This sketch was drawn over with india ink and made ready for the photolithographer. The advantage of this method over drawing upon a silver print, which is afterward 'dismissed' is that the drawing and tracing is done upon a larger picture than the final cut, and hence a coarser style may be employed and yet the desired fineness attained in the final reduced cut. Of course a projection lantern of some sort is desirable, but a very simple one will do. The conventional shading in the variometer was put in after the tracing was finished.

W. HALLOCK.

* On the day in question it snowed in the morning and cleared in the late afternoon.